

The Relation between a Country's GDP per capita and the Color of its Flag

Introduction

One of the main indicators of the size of a country's economy, and how that economy is performing, is its GDP. GDP, or Gross Domestic Product, represents the total value of goods and services produced by a country in a year. Economists can often measure the general health of the economy by the growth rate of the real GDP. Therefore, an increase in the real GDP of a country would mean that the economy is doing well at that specific time. In comparison, GDP per capita is the total value of all the goods and services produced by a country in a particular year, divided by the number of people living there. GDP per capita is generally thought to be more important, or relevant, than the GDP as it includes another important factor in economic growth; population. The main difference is that it takes into account the impact of population on Gross Domestic Rate. Seemingly unrelated, a country's flag design and colors represent its values, beliefs, and history. They hold significance special to the countries they are representing. Is there a relation between a country's GDP per capita and the color of its flag? In this experiment, I will investigate whether or not there is a difference in the distribution of GDP per capita for the separate flag colors.

Methodology

I started out by gathering data into a spreadsheet on all the countries' GDP per capita. Since there are a total of 189 countries that have an official GDP and GDP per capita, I listed each available country from one 1-189. I then proceeded to search an image for each country's flag, and examine which colors, out of red, white, blue, covered the majority of the area. I chose the colors red, white and blue because they are the most popular color combinations, according

to a chart by the Washington Post, and various other sources. I used eyeballing as a method of assigning a color, or colors, to each country. If a country had a majority of red/white/blue colors on its flag, I listed whichever of those it had. However, if a country had a majority of colors that were not either red, white, or blue, I marked it down as “Other” signifying another color. In certain cases, the countries that had an equivalent proportion of colors, such as the Netherlands with all red, white, and blue covering equal areas of the flag, I listed as having red, white, and blue. If a country had an area evenly covered by either red/white/blue and another color, I listed it as having whichever popular color it was, and “Other”. For example, Ukraine, with the colors blue and yellow, is written as “Blue and Other”. The distribution of primary colors in national flags is available in the appendix. I observed each and every flag for minutes to see whether it shared an equivalent area with another flag, or if each color was covering the majority space. For flags that were too close to certainly say which color, I used a ruler to evaluate which group it belonged to based on the areas covered by each color.

Analysis

Raw Data* as seen in the appendix of this document, shows the original list of each country with its GDP per capita, and primary flag color(s). There are a total of 189 countries that have an official GDP. The country numbers in the raw data holds no significance because the countries are in random order. In this experiment, we used a χ^2 to find a distribution under the null hypothesis. The null hypothesis is that the color of a country’s flag and its GDP per capita are independent of each other. The alternative hypothesis is that the color of a country’s flag and its GDP per capita are not independent of each other.

Chart 1: Country vs. GDP per capita

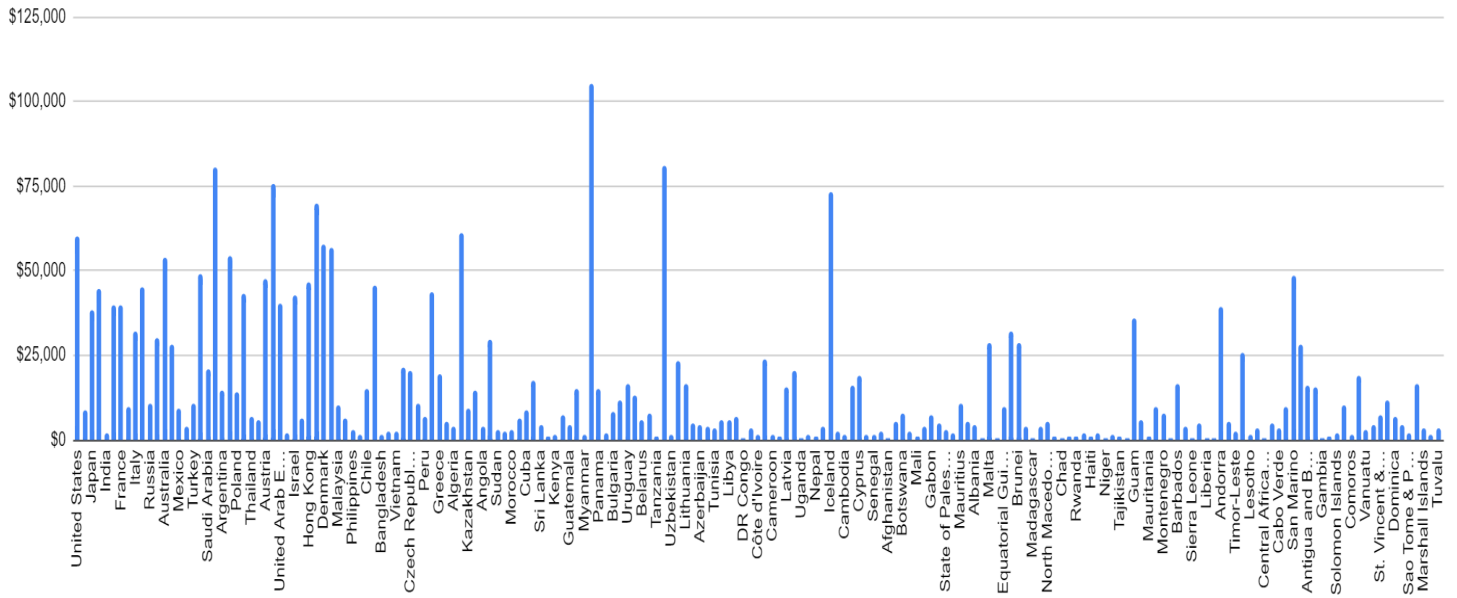
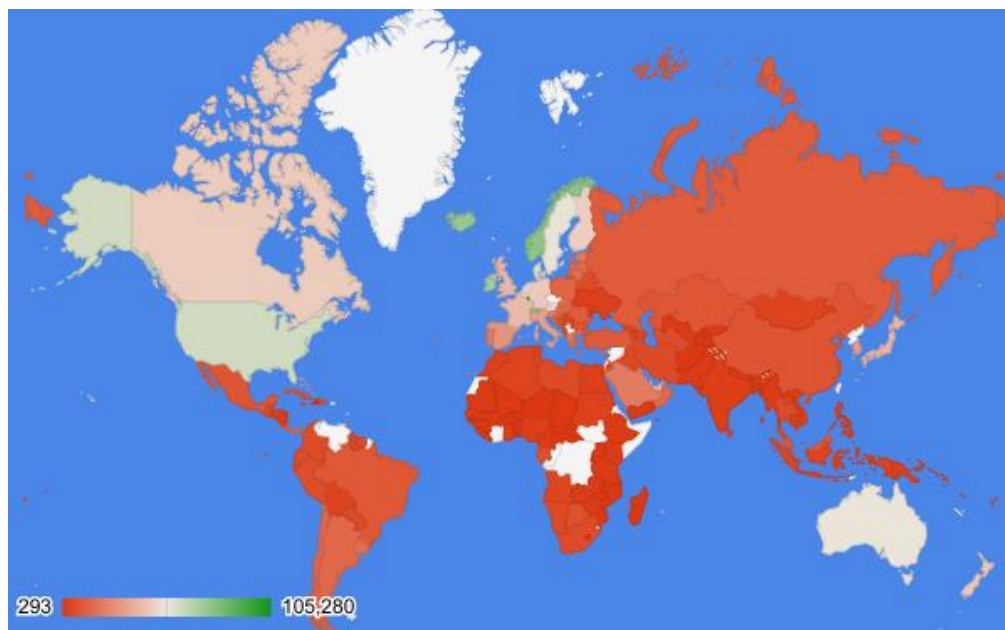


Chart 2: Geomap of GDP Distribution



The Geomap shows the distribution of GDP around the world. The color red represents the lower values down to the minimum; 293. The color green represents the higher values up to

the maximum; 105,280. The countries in white show no data as they did not have an official GDP listed. The geomap was simply for reference on the range of GDP per capita among each region. There seems to be a regional factor on the GDP per capita, with North America and Europe showing mainly higher values, which may be interesting to explore as a separate experiment in the future. The countries that have gained their independence earlier on, which includes the United States, Canada, and majority of Western Europe and the Nordic countries, seem to have higher rates of GDP per capita. A possible extension to the experiment could be finding the relation between a country's GDP per capita and when they gained their independence. The date of independence for each country is most likely similar to how old the national flags, which then the experiment would test the dependence between a country's GDP per capita and the date when their national flag was found.

Table 1: Observed Data

		Flag Color				Margin
		Primarily red	Primarily white	Primarily blue	Primarily other	Total
GDP Per Capita	>35k	13	9	9	6	37
	20-35k	8	4	4	4	20
	10-20k	17	8	12	7	44
	5-10k	17	3	9	14	43
	0-5k	33	10	23	53	119
Margin	Total	88	34	57	84	263

The observed data includes the country's GDP per capita listed on the columns and the country's primary flag color listed on the rows. In the columns, the three primary flag colors are

red, white, and blue. The “other” option contains the rest of all possible colors. In the rows, the data ranges are as stated: 0-4999, 5000-9999, 10000-19999, 20000-34999, and lastly any data point greater than 350000. To make the expected counts greater than 5, I specifically chose these ranges to spread out my data. Despite counting a total of 189 countries, since there could be multiple primary colors assigned to each flag, the total number came out to be 263. The three main colors evaluated in each flag were red, white, and blue. There was also an “other” group which included the rest of the countries who did not have flags that were dominated by the colors priorly listed. The ranges for the GDP per capita were distributed close to evenly, using the standard deviation of 19129. The five groups carry an appropriate range of each listed country’s GDP per capita, while keeping its random distribution from the minimum of \$293, to the maximum of \$105,280. Now having gathered the observed data, I found my expected data for each group using the formula below.

Table 2: Expected Data (Formula)

$$Expected = \frac{(row\ total \times\ column\ total)}{(table\ total)}$$

		Flag Color			
		Primarily red	Primarily white	Primarily blue	Primarily other
GDP Per Capita	>35k	(37x88)/(263)	(37x34)/(263)	(37x57)/(263)	(37x84)/(263)
	20-35k	(20x88)/(263)	(20x34)/(263)	(20x57)/(263)	(20x84)/(263)
	10-20k	(44x88)/(263)	(44x34)/(263)	(44x57)/(263)	(44x84)/(263)

	5-10k	(43x88)/(263)	(43x34)/(263)	(43x57)/(263)	(43x84)/(263)
	0-5k	(119x88)/(263)	(119x34)/(263)	(119x57)/(263)	(119x84)/(263)

Table 3: Expected Data (Simplified)

		Flag Color			
		Primarily red	Primarily white	Primarily blue	Primarily other
GDP Per Capita	>35k	12.38022814	4.783269962	8.019011407	11.81749049
	20-35k	6.692015209	2.585551331	4.33460076	6.3878327
	10-20k	14.72243346	5.688212928	9.536121673	14.05323194
	5-10k	14.3878327	5.558935361	9.319391635	13.7338403
	0-5k	39.81749049	15.38403042	25.79087452	38.00760456

$$x^2 = \sum \frac{(\text{observed} - \text{expected})^2}{(\text{expected})}$$

$$x^2 = \frac{(13 - 12.38022814)^2}{(12.38022814)} + \frac{(8 - 6.692015209)^2}{(6.692015209)} + \frac{(17 - 14.72243346)^2}{(14.72243346)} + \frac{(17 - 14.3878327)^2}{(14.3878327)} +$$

$$\begin{aligned}
& \frac{(33 - 39.81749049)^2}{(39.81749049)} + \frac{(9 - 4.783269962)^2}{(4.783269962)} + \frac{(4 - 2.585551331)^2}{(2.585551331)} \\
& \quad + \frac{(8 - 5.688212928)^2}{(5.688212928)} + \\
& \frac{(3 - 5.558935361)^2}{(5.558935361)} + \frac{(10 - 15.38403042)^2}{(15.38403042)} + \frac{(9 - 8.019011407)^2}{(8.019011407)} \\
& \quad + \frac{(4 - 4.33460076)^2}{(4.33460076)} + \\
& \frac{(12 - 9.536121673)^2}{(9.536121673)} + \frac{(9 - 9.319391635)^2}{(9.319391635)} + \frac{(23 - 25.79087452)^2}{(25.79087452)} \\
& \quad + \frac{(6 - 11.81749049)^2}{(11.81749049)} + \\
& \frac{(4 - 6.3878327)^2}{(6.3878327)} + \frac{(7 - 14.05323194)^2}{(14.05323194)} + \frac{(14 - 13.7338403)^2}{(13.7338403)} \\
& \quad + \frac{(53 - 38.00760456)^2}{(38.00760456)}
\end{aligned}$$

$$x^2 = 25.08440577$$

$$\text{Degrees of Freedom} = (\text{number of rows} - 1) \times (\text{number of columns} - 1)$$

$$(5 - 1) \times (4 - 1)$$

Degrees of Freedom = 12

$$25.08440577 > 21.03$$

Using the chi-squared distribution table, the level of significance for a degree of freedom of 12 is 21.03. There is no difference in the distribution of GDP for the separate flag colors. The calculated test statistic is greater than the critical value.

Evaluation

I fail to reject the null hypothesis and reject the alternative hypothesis as our p-value of 25.08440577 was greater than the level of significance of 21.03. The results are not significant and suggest an independence between the color of a country's flag and its GDP per capita. If I were to conduct this experiment in the future, I would only choose one color to represent the flag of each country. Since I used a combination of estimates and measurements to come up with the dominant color for each country's flag, there could have been up to four different colors for each flag. The data would be easier to control if there was only one designated color for each flag. Originally, I did not plan for there to be multiple colors per flag but flags such as Germany, Italy, Belgium have the same three colors covering an equal area of the flag. I could not just pick one color randomly as I was testing for a correlation, however, in the future I could designate which area to look at specifically in that situation, for example choosing the color that is in the middle. In addition, I faced a lot of issues counting the numbers and often lost my place. Therefore, I had to individually color code the data for each country based on the range of its GDP per capita.* I had to check my work repeatedly to ensure that there were no mistakes. In the future experiment, I would rather calculate the categories for each country using a code to do it on Microsoft Excel. A strength of this experiment is the availability of our raw data on an online demographics website. I was able to access the GDP and GDP per capita for all of the UN recognized nations in the world, which helped me in gathering and analyzing the data faster.

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Appendix I

Distribution of primary colors in national flags

Example 1: Primarily red color flag



Example 3: Primarily white color flag



Example 2: Primarily blue color flag



Example 4: Primarily other color flag



Example 5: Equally red, white, and other color flag



Appendix II

Raw Data*

#	Country	GDP per capita	Primary Flag Color
1	United States	\$59,939	Red
2	China	\$8,612	Red
3	Japan	\$38,214	White
4	Germany	\$44,680	Other
5	India	\$1,980	Other
6	United Kingdom	\$39,532	Red
7	France	\$39,827	Red, White, Blue
8	Brazil	\$9,881	Other
9	Italy	\$32,038	White, Red
10	Canada	\$44,841	Red
11	Russia	\$10,846	Red, White, Blue
12	South Korea	\$29,958	White
13	Australia	\$53,831	Blue
14	Spain	\$28,175	Red

15	Mexico	\$9,224	Red
16	Indonesia	\$3,837	Red, White
17	Turkey	\$10,498	Red
18	Netherlands	\$48,796	Red, White, Blue
19	Saudi Arabia	\$20,747	Other
20	Switzerland	\$80,296	Red
21	Argentina	\$14,508	Blue
22	Sweden	\$54,075	Blue
23	Poland	\$13,871	Red, White
24	Belgium	\$43,325	Other
25	Thailand	\$6,579	Red, White, Blue
26	Iran	\$5,628	Red, White
27	Austria	\$47,261	Red
28	Norway	\$75,428	Red
29	United Arab Emirates	\$40,325	Red, White, and Other

30	Nigeria	\$1,969	Other
31	Israel	\$42,852	White
32	South Africa	\$6,120	Other
33	Hong Kong	\$46,733	Red
34	Ireland	\$69,727	Other
35	Denmark	\$57,545	Red
36	Singapore	\$56,746	White
37	Malaysia	\$10,118	Red
38	Colombia	\$6,429	Other
39	Philippines	\$2,982	Red and Blue
40	Pakistan	\$1,467	Other
41	Chile	\$15,001	Red
42	Finland	\$45,778	White
43	Bangladesh	\$1,564	Other
44	Egypt	\$2,441	Red and Other

45	Vietnam	\$2,366	Red
46	Portugal	\$21,316	Red
47	Czech Republic (Czechia)	\$20,291	Red and White
48	Romania	\$10,781	Red, Blue, Other
49	Peru	\$6,723	Red
50	New Zealand	\$43,415	Blue
51	Greece	\$19,214	Blue
52	Iraq	\$5,114	Red and Other
53	Algeria	\$4,048	Other
54	Qatar	\$61,264	Red
55	Kazakhstan	\$9,009	Blue
56	Hungary	\$14,364	Red, White, Other
57	Angola	\$4,096	Other
58	Kuwait	\$29,616	Red and Other
59	Sudan	\$2,879	Red and Other

60	Ukraine	\$2,521	Blue and Other
61	Morocco	\$3,083	Red
62	Ecuador	\$6,214	Other
63	Cuba	\$8,541	Red
64	Slovakia	\$17,551	Red and White
65	Sri Lanka	\$4,135	Other
66	Ethiopia	\$757	Red and Other
67	Kenya	\$1,578	Other
68	Dominican Republic	\$7,223	Red and Blue
69	Guatemala	\$4,471	Blue
70	Oman	\$15,170	Red
71	Myanmar	\$1,256	Red and Other
72	Luxembourg	\$105,280	Red, White, Blue
73	Panama	\$15,166	Red and Blue
74	Ghana	\$2,026	Red and Other

75	Bulgaria	\$8,197	Red, White, Other
76	Costa Rica	\$11,573	Blue, White
77	Uruguay	\$16,341	Blue
78	Croatia	\$13,200	Red and White
79	Belarus	\$5,762	Red
80	Lebanon	\$7,857	Red
81	Tanzania	\$975	Blue and Other
82	Macao	\$80,890	Other
83	Uzbekistan	\$1,554	White and Other
84	Slovenia	\$23,488	Red
85	Lithuania	\$16,709	Other
86	Serbia	\$4,692	Red and White
87	Azerbaijan	\$4,139	Blue and Other
88	Jordan	\$4,095	Other
89	Tunisia	\$3,494	Red

90	Paraguay	\$5,776	Red and Blue
91	Libya	\$5,791	Other
92	Turkmenistan	\$6,587	Other
93	DR Congo	\$462	Blue
94	Bolivia	\$3,351	Other
95	Côte d'Ivoire	\$1,529	Other
96	Bahrain	\$23,715	Red
97	Cameroon	\$1,422	Other
98	Yemen	\$1,123	Red, White, Other
99	Latvia	\$15,613	Red
100	Estonia	\$20,170	Blue, White, Other
101	Uganda	\$631	Other
102	Zambia	\$1,535	Other
103	Nepal	\$900	Red
104	El Salvador	\$3,883	Blue

105	Iceland	\$73,233	Blue
106	Honduras	\$2,437	Blue
107	Cambodia	\$1,384	Blue
108	Trinidad and Tobago	\$15,952	Red
109	Cyprus	\$18,695	White
110	Zimbabwe	\$1,548	Other
111	Senegal	\$1,366	Red and Other
112	Papua New Guinea	\$2,434	Red and Other
113	Afghanistan	\$538	Other
114	Bosnia and Herzegovina	\$5,387	Blue
115	Botswana	\$7,894	Blue
116	Laos	\$2,424	Red
117	Mali	\$828	Other
118	Georgia	\$3,762	White
119	Gabon	\$7,271	Other

120	Jamaica	\$5,061	Other
121	State of Palestine	\$3,054	Other
122	Nicaragua	\$2,164	Blue
123	Mauritius	\$10,491	Red, Blue, Other
124	Namibia	\$5,516	Blue and Other
125	Albania	\$4,521	Red
126	Mozambique	\$441	Other
127	Malta	\$28,585	Red
128	Burkina Faso	\$642	Red and Other
129	Equatorial Guinea	\$9,741	Red and Other
130	Bahamas	\$31,858	Blue
131	Brunei	\$28,572	Other
132	Armenia	\$3,918	Red, Blue, Other
133	Madagascar	\$450	Red and Other
134	Mongolia	\$3,672	Red

135	North Macedonia	\$5,418	Red
136	Guinea	\$868	Other
137	Chad	\$657	Red, Blue, Other
138	Benin	\$827	Other
139	Rwanda	\$762	Blue
140	Congo	\$1,703	Other
141	Haiti	\$766	Red and Blue
142	Moldova	\$2,002	Red and Blue
143	Niger	\$376	Other
144	Kyrgyzstan	\$1,222	Red
145	Tajikistan	\$805	White
146	Malawi	\$357	Other
147	Guam	\$35,665	Blue
148	Fiji	\$5,768	Blue
149	Mauritania	\$1,173	Other

150	Maldives	\$9,802	Red
151	Montenegro	\$7,720	Red
152	Togo	\$618	Other
153	Barbados	\$16,328	Blue
154	Eswatini	\$3,942	Blue
155	Sierra Leone	\$504	Blue, White, Other
156	Guyana	\$4,671	Other
157	Liberia	\$699	Red
158	Burundi	\$293	White
159	Andorra	\$39,128	Other
160	Suriname	\$5,251	Red
161	Timor-Leste	\$2,377	Red
162	Aruba	\$25,630	Blue
163	Lesotho	\$1,233	Blue, White, Other
164	Bhutan	\$3,391	Other

165	Central African Republic	\$424	Other
166	Belize	\$4,957	Blue
167	Cabo Verde	\$3,298	Blue
168	Saint Lucia	\$9,602	Blue
169	San Marino	\$48,495	Blue and White
170	Northern Mariana Islands	\$28,164	Blue
171	Antigua and Barbuda	\$15,825	Red
172	Seychelles	\$15,536	Red, Blue, White, Other
173	Gambia	\$673	Red and Other
174	Guinea-Bissau	\$737	Other
175	Solomon Islands	\$2,049	Other
176	Grenada	\$10,164	Other
177	Comoros	\$1,312	Red, Blue, White, Other
178	Saint Kitts & Nevis	\$19,061	Red and Other
179	Vanuatu	\$3,022	Red and Other

180	Samoa	\$4,305	Red
181	St. Vincent & Grenadines	\$7,150	Other
182	American Samoa	\$11,399	Blue
183	Dominica	\$6,951	Other
184	Tonga	\$4,193	Red
185	Sao Tome & Principe	\$1,896	Other
186	Palau	\$16,275	Blue
187	Marshall Islands	\$3,517	Blue
188	Kiribati	\$1,626	Red
189	Tuvalu	\$3,494	Blue

Color Coded Sheet*

#	Country	GDP per capita	Primary Flag Color
1	United States	\$59,939	Red
2	China	\$8,612	Red
3	Japan	\$38,214	White
4	Germany	\$44,680	Other
5	India	\$1,980	Other
6	United Kingdom	\$39,532	Red
7	France	\$39,827	Red, White, Blue
8	Brazil	\$9,881	Other
9	Italy	\$32,038	White, Red
10	Canada	\$44,841	Red
11	Russia	\$10,846	Red, White, Blue
12	South Korea	\$29,958	White
13	Australia	\$53,831	Blue
14	Spain	\$28,175	Red
15	Mexico	\$9,224	Red
16	Indonesia	\$3,837	Red, White
17	Turkey	\$10,498	Red
18	Netherlands	\$48,796	Red, White, Blue
19	Saudi Arabia	\$20,747	Other
20	Switzerland	\$80,296	Red
21	Argentina	\$14,508	Blue
22	Sweden	\$54,075	Blue
23	Poland	\$13,870	Red, White
24	Belgium	\$43,325	Other
25	Thailand	\$6,579	Red, White, Blue
26	Iran	\$5,628	Red, White
27	Austria	\$47,261	Red
28	Norway	\$75,428	Red
29	United Arab Emirates	\$40,325	Red, White, and Other
30	Nigeria	\$1,969	Other
31	Israel	\$42,852	White
32	South Africa	\$6,120	Other
33	Hong Kong	\$46,733	Red
34	Ireland	\$69,727	Other
35	Denmark	\$57,545	Red
36	Singapore	\$56,746	White
37	Malaysia	\$10,118	Red
38	Colombia	\$6,429	Other
39	Philippines	\$2,982	Red and Blue
40	Pakistan	\$1,467	Other
41	Chile	\$15,001	Red